AC and DC Current Dependence of On-Chip Inductors

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The prospect of a monolithic, on-chip DC-DC converter has spurred much of the development in on-chip inductors. In these converters, the inductor's ability to perform while sustaining a DC current is vital. For example, in a buck converter the same DC current flows through the inductor as through the load. Because the permeability of magnetic materials is in general a highly nonlinear function of the applied field, the properties of inductors with magnetic cores depend on the amplitude of the oscillating current and any DC current through them. This problem has been investigated for some on-chip spiral inductors in reference 1. We have characterized MEMS inductors as a function of applied current. As is well known in discrete devices, the flux concentration achieved by the gapless toroid provides higher inductance per unit area and generally less stray field than the gapped toroid, but also saturates the core at lower currents, limiting its useful range.

These inductors were fabricated as described in reference 2. They are 4mm by 1.5mm by 120μm with 70 turn copper coils plated around a Permalloy core. The gaps are on the order of 40 microns long.

The dependence of the inductance of two ungapped toroids and two toroids with gaps measured with a QuadTech 7600 CLR meter at 1kHz is presented in Figure 1. Figures 2 and 3 show the inductance of the closed toroids as measured with a Hewlett Packard 4285A LCR meter with constant current option. Although the inductance of the ungapped toroid with no DC bias and a 10mArms exciting field at 1kHz is excellent, it is very sensitive to the current values. The operating range of inductors with this topology may be increased in the gapped structures or perhaps by plating the core in an external magnetic field. These options and others including spiral topologies will be discussed as means to provide useful on-chip inductors for monolithic DC-DC converters.

1. S. Sugahara, Z. Hayashi, M. Edo, Y. Katayama, M. Gikinozu, K. Matsuzaki, A. Matsuda, E. Yonzawa, K. Kuroki, "Characteristics of a Monolithic DC-DC Converter utilizing a Thin-film Inductor" IPEC Tokyo 2000 p.326-330

2. T. M. Liakopoulos and C. H. Ahn, "Microfabricated Planar Toroidal-Type Planar Inductors for MEMS and Power Electronic Applications," 194th Meeting of the Electrochemical Society, Boston, MA, Nov. 1-6, 1998.

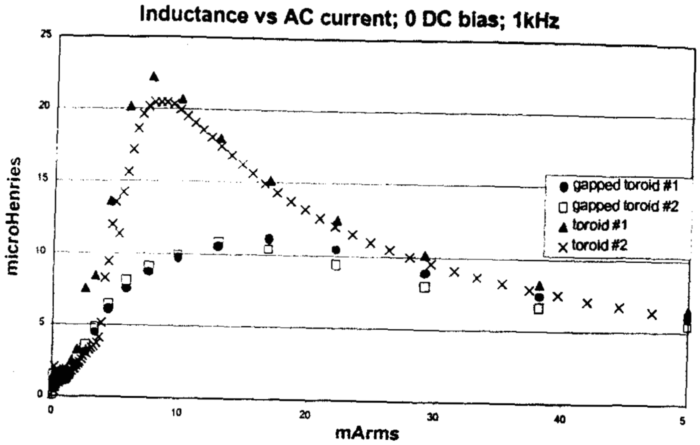


Figure1.

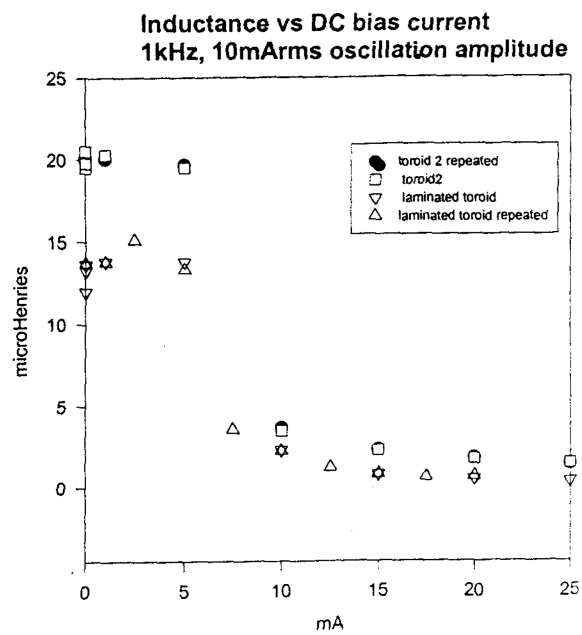


Figure2

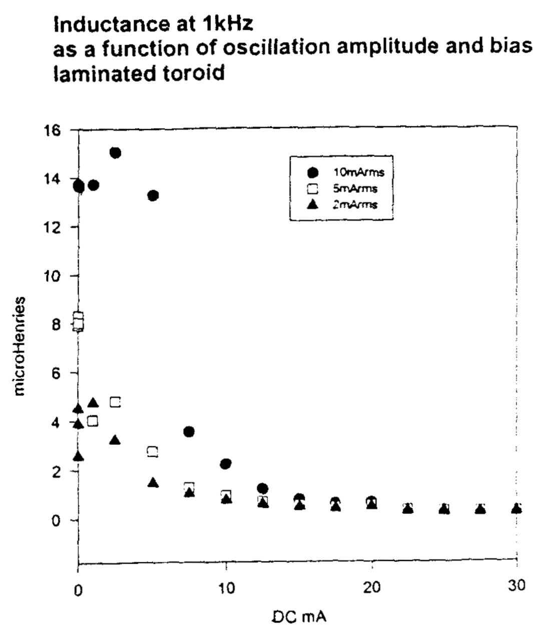


Figure 3.